SEMI-ANNUAL PROGRESS REPORT ON AN INSTITUTIONAL RESEARCH PROGRAM IN SPACE-RELATED AREAS OF SCIENCE AND ENGINEERING

Grant NsG-682

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Submitted by:

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SECTION I

General Statement Concerning the Status of the Program

The NASA Multi-disciplinary Research Grant currently in effect began on June 1, 1964 and was renewed for an additional ten-month period on June 1, 1965. The general policy which has been followed in the internal allocation of the grant funds has been to provide continuing support for the University's High Energy Physics Program being carried out at the NASA Space Radiation Effects Laboratory and to utilize the remaining funds to seed promising new research programs in the space-related sciences.

The High Energy Physics Program has made impressive progress in the design, construction, and testing of experimental apparatus which will be ready for use when the SREL Synchrocyclotron is available for experiments. One of the major pieces of equipment is a completely automated sonic spark chamber which is completed and in operation.

As a seeding operation, the program supported by the grant has enjoyed further success. The following projects, initiated under the Multi-disciplinary Grant, are now well established and are supported by the indicated project grants:

1. Astrometric Observation Program (Dr. L. W. Fredrick), now supported by NSF.

2. Measurement of the Gravitational Constant using Constant Speed Rotors (Dr. J. W. Beams), now supported by a NASA project grant.

3. High Lift Wind Tunnel Wall Interference (Dr. G. B. Matthews), now supported by a NASA project grant.

During the past year, research efforts in the Department of Aerospace Engineering culminated in a significant advance with regard to the preparation of molecular beams. The flexibility inherent in the Multi-

disciplinary Grant concept made it possible to begin immediate construction of a new aerodynamic molecular beam apparatus which will be an important new tool in the study of gas-surface and gas-gas interactions. This program will require continued funding at a level substantially higher than that possible under the Multi-disciplinary Grant. The principal investigators have recently received informal indication from NASA that such support will very likely be forthcoming. The present support of the program will make it possible to essentially complete the construction of the major equipment involved by the time that full funding is available.

In the Department of Astronomy, also, the flexibility allowed in the administration of the grant made it possible to allocate immediate support to a newly appointed member of the faculty for the initiation of a program involving the observation of interstellar clouds. This possibility for immediate funding of unusually promising programs of research has proved to be one of the most significant and useful features of the Multi-disciplinary Grant.

Personnel participating in the various programs being supported at the present time include twenty faculty members, four research associates (including two post-doctoral fellows), and fifteen graduate students.

SECTION II

Status of Work Under the Various Sub-grants

G1 EXPANSION OF THE OBSERVATORY'S ASTROMETRY PROGRAM.

Principal Investigator: Laurence W. Fredrick, Associate Professor of Astronomy

Under this program 22 stellar parallaxes have been completed. A note on these parallaxes will be published in the Astronomical Journal when the material is complete, and details will be given in a future issue of the McCormick Observatory Publications.

Switching of the remaining stars to the program now supported by NSF is underway. Thus, in this case the seeding operation is succeeding.

Final work on the new parallax tailpiece for the telescope will be completed during the remainder of this grant.

G2 OBSERVATION OF INTERSTELLAR CLOUDS

Principal Investigator: Samuel J. Goldstein, Associate Professor of Astronomy

Since this is a new program, begun in October, 1965, and not described in previous proposals or reports, it is described here in some detail.

One approach to the study of interstellar clouds is to observe the 21-cm emission line from isolated clouds that extend over many antenna beams on the celestial sphere. For such a cloud an average velocity can be obtained independently in many different directions and the following properties of the cloud can be deduced:

1. Apparent space velocity. A solar motion solution is made by finding the solar vector which minimizes the sum

(observed velocity - component of sun's velocity in observed direction)^2

If the cloud does not rotate the apparent space velocity is the true velocity.

2. Velocity of expansion or contraction. After the observed velocities are corrected for the solar motion, the presence of expansion or contraction of the cloud can be detected from the systematic shift which velocities measured near the edges will have with respect to the velocities near the center.

A study of one interstellar cloud has been made in this way (Goldstein and Welch, 1965). Similar results on other clouds may allow comparison with existing optical observations of interstellar lines and a statistical determination of whether or not the 21-cm clouds rotate.

The velocity measuring instrument will be an accessory to the NRAO hydrogen line receiver and will be used with any of the fully steerable NRAO telescopes. It will contain two filters that are shifted together in frequency so that one lies on each of the sides of the interstellar emission line. The difference in the power output of the two filters controls the shifting frequency which is also read out by the electronic counter and printer. In effect, then, the velocity measuring instrument automatically matches an internal replica of the emission line to the real one in the sky and gives an immediate measurement of a frequency which is a linear function of the velocity of an interstellar cloud.

The integration time for the measurement is controlled by the electronic counter, and can easily be made as large as 100 sec.

The expected accuracy for this instrument with the present NRAO receiver and with 100 sec integration time can be shown to be an order of magnitude greater than has been achieved before.

The velocity measuring instrument will constitute a large fraction of the equipment needed for a future experiment, an attempt to measure Zeeman splitting of the 21-cm line.

G3 CONSTRUCTION AND USE OF A PHOTOELECTRIC PHOTOMETER.

Principal Investigator: D. S. Birney, Assistant Professor of Astronomy

The observational program on eclipsing binary stars is continuing. This project utilizes a photoelectric photometer and a current integrator which were constructed for the new telescope at the University's Fan Mountain Observatory.

G4 HEMOLYSIS OF RED BLOOD CELLS INDUCED BY ULTRAVIOLET RADIATION.

Principal Investigator: S. P. Maroney, Jr., Professor of Biology

It was previously found that the rate of ultraviolet-induced hemolysis of frog erythrocytes was directly proportional to pH. In the current report, an attempt was made to separate the effect of pH during irradiation (associated with the photochemical effect) from the effect of pH following irradiation (associated with the prolytic changes - ion and water movements - that precede hemoglobin loss).

The results indicate that the rate of hemolysis varied directly with the pH of the medium following irradiation. There was some decrease in hemolysis rate when low pH was used during radiation but this could be nullified by high pH following radiation. It

is concluded that the pH of the medium following irradiation is more important in determining the rate of hemolysis than the pH during radiation.

A paper embodying these results is planned for the Virginia Academy of Science meeting in May, 1966.

Publications: "Ultraviolet Induced Hemolysis of Frog Erythrocytes," S. P. Maroney, Jr., Assoc. S. E. Biol. Bull. 12(2):48

G5 EFFECT OF CHLORIDES OF RARE EARTHS ON THE DEVELOPMENT OF CHICK EMBRYOS.

Principal Investigator: Howard L. Hamilton, Professor of Biology

Localization of Radioactive Cerium (Ce^{141}) in the yolk sac of the chick was studied in two ways. Ten microcuries (as 10 mg. of cerium chloride) were dissolved in 0.1 ml. of Ringer's solution and injected directly into the yolk of each unincubated egg. Between states 10 to 26 (2½-5 days) after incubation, embryos were removed, and samples of the yolk beneath the blastoderm, samples of the area vasculosa and the area vitellina, and the whole embryo itself, were tested for radioactivity by use of a Geiger-Muller tube and a Bird Atomic G-M Scaler, model 123. Eggs incubated to stages 10-20 were also injected, and counts made after two days (stages 24-28) to test whether uptake of the isotope continued beyond stage 10.

The data on gross radioactivity obtained from the above experiments were variable, depending upon the site of deposition of the isotope within the yolk. Apparently, the isotope is tied up at the site of injection by combination with the phosphoproteins

of the yolk. When deposited deep beneath the blastoderm, it does not become available to the embryo until the yolk complexes are dissolved by enzymatic activity of the yolk sac entoderm. Although there is variability in the intensity of the activity, due to availability, the data are clear in showing that cerium localizes in the area vitellina, the area vasculosa, and the blood, but not significantly within the tissues of the embryo itself.

To localize the site of uptake more precisely, the portion of the blastoderm which contained the areas vitellina and vasculosa in treated embryos was fixed in Bouin's fluid, sectioned at 4 microns, and mounted on glass slides. The sections were treated with Ilford L-4 liquid emulsion, and let stand in the dark for 5-20 days. After exposure, the slides were developed and then stained with Harris' hematoxylin and eosin. The grana of reduced silver produced by Ce^{141} were most abundant in the small yolk spheres which are composed of white yolk and thus contain the highest percentage of phosphoprotein. Very little radioactivity was found in the large globules of yellow yolk which contain mostly lipids. The entodermal cells of the area vitellina contained silver grains in the yolky parts of their cytoplasm where yolk globules had been ingested and were being absorbed. Within the area vasculosa, the radioactivity was localized within the nuclei of the entodermal cells, and particularly inside the nucleoli. After state 15, activity was also found in the nuclei of the primary erythrocytes, but not in their cytoplasm. These experiments indicate that the rare earths are tied up almost immediately by the phosphoproteins of the yolk, that their portal of entry to the

embryo is through the entodermal cells which digest the yolk, and that the erythropoietic cells are closely associated with the entoderm.

Two manuscripts are in preparation.

G6 CHEMISTRY IN MOLTEN SALTS.

Principal Investigator: E. R. Van Artsdalen, John W. Mallet Professor of Chemistry

A number of low melting inorganic salts contain constitutional protons, either as water of hydration (crystallization) or as protonic acids. The physical and chemical behavior of such salts in the fused (molten) state is imperfectly understood, although these salts are important technologically and offer almost unique opportunity to bridge the gap between very concentrated aqueous solutions and fused anhydrous salts. We have been studying the structure and electrochemistry of several fused acid salts and hydrates, such as acid sulfates, phosphates and arsenates. Principal techniques used have been precision NMR spectroscopy, electrical conductivity, transport phenoma including determination of transference numbers, and we are beginning IR spectroscopic measurements.

The most interesting discovery has been that the protons in a melt such as $NaHSO_4.H_2O$ move rather freely and cannot be assigned to either water or sulfate ions alone. The NMR spectra suggest strong hydrogen bonding; there is evidence for one kind of proton only.

G7 PHOTOCHEMICAL REACTIONS USING FLASH PHOTOLYSIS.

Principal Investigator: Thomas A. Gover, Assistant Professor of Chemistry

Work is continuing with the flash photolysis apparatus on studies of photochemical reactions.

G8 HIGH ENERGY NUCLEAR PHYSICS.

Principal Investigators: Klaus Ziock, Associate Professor of Physics
S. Sobottka, Associate Professor of Physics

1. Personnel

In addition to the Principal Investigators another faculty position is available and negotiations with several applicants are proceeding.

One electronics engineer, one mechanical engineer, and one machinist are working full time on the program. Four graduate students are participating in the program, working on their Ph.D. theses, and we expect a large increase in this number during the coming semester.

2. Theoretical Work

Professor J. Nilsson, in cooperation with Dr. H. Pietschmann, has presented a series of lectures on weak interactions of strange and non-strange particles which will be published in book form.

A consistent theory of weak interactions based on a unitary S operator has also been developed by Dr.'s Nilsson and Pietschmann and has been submitted for publication to Physical Review.

Professors J. M. Eisenberg and M. E. Rose and their students are working on the theoretical aspects of various problems we are preparing or considering to study experimentally.

3. Experimental Work

Our preparations for a measurement of the angular distribution of particles emitted following pion capture in light nuclei are progressing well.

We plan to measure the angular distributions with two large sonic spark chambers.

Techniques for the fabrication of the thin-foil chambers have been worked out and the first modules have been built and tested successfully.

Techniques for the manufacture of large - 30 inch wide - lightpipes have also been developed and lightpipes of ¼, and ½ inch thickness and 30' width have been built.

A Monte-Carlo program for the computation of the neutron sensitivity of our spark chambers has been written and is presently being compared with experimental results obtained with monochromatic neutrons of 14 MeV from our Van de Graaff generator. The agreement between theory and experiment in preliminary measurements and the effects of nuclear de-excitation gamma rays, are being explored.

The system has been tested and works to our complete satisfaction. A computer program for the analysis of the digitized spark chamber readout has been written. A large number of cosmic ray events have been recorded with the spark chamber, their coordinates have been determined with the computer program and have then been plotted. Fig. 2 shows a computer plot of a small sample of these events, clearly outlining the counter telescope used to trigger the spark chamber.

A dual (2 x 1024 channels) analog to digital converter has been purchased and modified to be read out by the above mentioned read out system.

E1 SHELL STRUCTURES UNDER ASYMMETRIC DYNAMIC LOADING.

Principal Investigator: R. L. Jennings, Assistant Professor of Civil Engineering

This investigation, which is nearing completion, is presently involved with the accumulation of computer results for the natural frequencies of vibration of thin shells of revolution. The results of this study are discussed in a paper being submitted for publication in the Structural Division Journal of the American Society of Civil Engineers.

A significant outgrowth of this investigation has been the development of a new concept for the prediction of natural frequencies of vibration of rings. The hypothesis used in this concept will be examined critically by Mr. David C. Chang, presently employed as a 1/2-time research assistant on this project, who will base his doctoral dissertation in Applied Mechanics on the study.

E2 MOTION TRANSFORMATION OF PLANE MECHANISMS.

Principal Investigator: D. W. Lewis, Associate Professor of Mechanical Engineering

The NASA Institutional Grant supporting this work will likely result in a publication by NASA titled, "Kinematic Transformations of Several Mechanisms." The writing of this paper is presently in progress with the majority of the graphical work already completed.

E3 CONSTRUCTION OF A NEW AND IMPROVED AERODYNAMIC MOLECULAR BEAM.

Principal Investigators: J. E. Scott, Jr., Professor of Aerospace Engineering
A. R. Kuhlthau, Professor of Aerospace Engineering

This grant was specifically for the procurement of equipment and services for the construction of a new and improved molecular beam apparatus for use in the graduate research program of the Department of Aerospace Engineering and Engineering Physics. The new apparatus would be unique in the country and would present new opportunities for definitive measurements in the areas of gas-surface interactions, and both elastic and inelastic gas-gas interactions.

The design of the beam system is now complete and the major components are either on hand or have been ordered. The remainder of the grant funds will be allocated during January.

Assembly of the apparatus will begin on January 17th, and the beam is expected to be in operation by late spring or early summer, which was the original target date.

Four faculty members, one research associate, and 3 graduate students have been associated with the design and development of this new beam.

M1 NEURAL CONTROL OF MOTOR SYSTEMS.

Principal Investigator: Dr. George R. Hanna, Assistant Professor of Neurology

Since the last progress report, through May 1965, the histology technician has been sent to Columbia University for additional special training in the silver impregnation methods of

Nauta and Gygax. The histology laboratory is now productive of this specialized material as well as the more standard methods.

Data collection and analysis on the first phase is nearing completion--(Anatomico-physiologic correlation of thalamo-cortical motor projections). The second phase, closely related to the first, has begun--(Anatomico-physiologic correlation of cerebello-thalamic projections).

M2 THE EFFECTS OF X-RADIATION ON THE BRAIN.

Principal Investigator: Dr. Martin G. Netsky, Professor of Neuropathology

This program has been broadened in the extension of the studies to wound-induced inflammation of the brain. The current work has concentrated on the relation of immunity to inflammation. Gamma-globulins are suppressed by removal of the thymus in newborn mice, or, in young and old animals by administration of methotrexate. Stab-wounds are made in the brain by two methods: direct needling with retention of injured tissue, and needling with removal of a core of cerebral tissue. Studies are now underway to determine the effects of type of wound, age of experimental animal and suppression of immune mechanisms on reactivity.

Previously obtained results on the effects of X-radiation were reported in the following paper:

D. W. McKwel, Jr., "Acute and Chronic Responses of Rat Cerebrovascular System to Focal Cerebral X-radiation and Modification of the Acute Response by Drugs." VII Symposium Neuroradiologicum, 1964 (Abstract).